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(54) Abstract Title

Antiinflammatory dihydropyridines

(57) Certain novel 1,4-dihydro-1,4-diphenylpyridine derivatives are useful for the treatment of acute and chronic inflammatory processes, especially chronic obstructive pulmonary diseases.

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1,4-Dihydro-1,4-diphenylpyridine derivatives

The present invention relates to novel 1,4-dihydro-1,4-diphenylpyridine derivatives, processes for their preparation, and their use in medicaments, especially for the treatment of chronic obstructive pulmonary diseases.

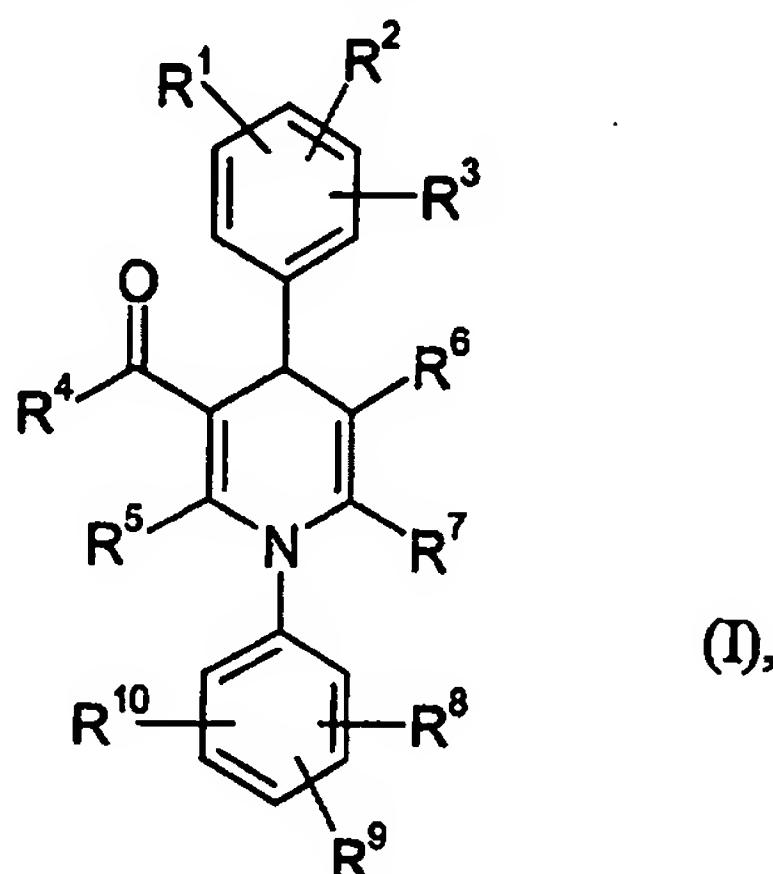
The fibrous protein elastin, which comprises an appreciable percentage of all protein content in some tissues, such as the arteries, some ligaments and the lungs, can be hydrolysed or otherwise destroyed by a select group of enzymes classified as elastases.

Human leukocyte elastase (HLE, EC 3.4.21.37), also known as human neutrophil elastase (HNE), is a glycosylated, strongly basic serine protease and is found in the azurophilic granules of human polymorphonuclear leukocytes (PMN). HNE is released from activated PMN and has been implicated causally in the pathogenesis of acute and chronic inflammatory diseases. HNE is capable of degrading a wide range of matrix proteins including elastin, and in addition to these actions on connective tissue HNE has a broad range of inflammatory actions including upregulation of IL-8 gene expression, oedema formation, mucus gland hyperplasia and mucus hypersecretion. Pulmonary diseases where HNE is believed to play a role include lung fibrosis, pneumonia, acute respiratory distress syndrome (ARDS), pulmonary emphysema, including smoking-induced emphysema, chronic obstructive pulmonary diseases (COPD) and cystic fibrosis. HNE has also been causally implicated in rheumatoid arthritis, atherosclerosis, brain trauma, cancer and related conditions in which neutrophil participation is involved. Thus, inhibitors of HLE activity can be potentially useful in the treatment of a number of inflammatory diseases, especially of chronic obstructive pulmonary diseases [R.A. Stockley, *Neutrophils and protease/antiprotease imbalance*, Am. J. Respir. Crit. Care 160, S49-S52 (1999)].

Certain cationic amphiphilic 1,4-dihydropyridine derivatives useful for delivery of nucleotide containing compounds are disclosed in WO-A1-01/62946. Ethyl 6-amino-1,4-bis(4-chlorophenyl)-5-cyano-2-methyl-1,4-dihydro-3-pyridinecarboxylate has been

synthesized and tested for potential antimicrobial activity as described in A.W. Erian et al., *Pharmazie* 53 (11), 748-751 (1998).

The present invention relates to compounds of the general formula (I)



5

wherein

R¹, R², R³, R⁸, R⁹ and R¹⁰ independently from each other represent hydrogen, halogen, nitro, cyano, trifluoromethyl, C₁-C₆-alkyl, C₁-C₆-alkanoyl, hydroxy, C₁-C₆-alkoxy, trifluoromethoxy, amino, mono- or di-C₁-C₆-alkylamino, C₁-C₆-acylamino, C₁-C₆-alkoxycarbonylamino, carboxyl, C₁-C₆-alkoxy-carbonyl or phenyl, wherein C₁-C₆-alkyl, C₁-C₆-alkanoyl, C₁-C₆-alkoxy, mono- or di-C₁-C₆-alkylamino and C₁-C₆-acylamino can be further substituted with one to three identical or different radicals selected from the group consisting of hydroxy, C₁-C₄-alkoxy, amino, mono- and di-C₁-C₄-acylamino,

10 R⁴ represents C₁-C₆-alkyl, trifluoromethyl or phenyl,

15 R⁵ represents C₁-C₄-alkyl,

R⁶ represents cyano, carboxyl or C₁-C₆-alkoxycarbonyl, wherein the alkoxy moiety can be further substituted with a radical selected from the group consisting of hydroxy, C₁-C₄-alkoxy, amino, mono- and di-C₁-C₄-acylamino,

and

R⁷ represents hydrogen, C₁-C₄-alkyl or amino.

5

In another embodiment, the present invention relates to compounds of general formula (I), wherein

R¹ represents hydrogen,

10

R², R³, R⁹ and R¹⁰ independently from each other represent hydrogen, halogen, nitro, cyano, trifluoromethyl, C₁-C₄-alkyl, C₁-C₄-alkanoyl, hydroxy, C₁-C₄-alkoxy, trifluoromethoxy, amino, C₁-C₄-dialkylamino, C₁-C₄-acylamino, methoxy-carbonylamino, tert.-butoxycarbonylamino, carboxyl, methoxycarbonyl or ethoxycarbonyl, wherein C₁-C₄-alkyl, C₁-C₄-alkanoyl, C₁-C₄-alkoxy, C₁-C₄-dialkylamino and C₁-C₄-acylamino can be further substituted with one to two identical or different radicals selected from the group consisting of hydroxy, methoxy, ethoxy, amino, dimethylamino and diethylamino,

15

20

R⁴ represents methyl, ethyl, trifluoromethyl or phenyl,

R⁵ represents methyl or ethyl,

25

R⁶ represents cyano, carboxyl or C₁-C₄-alkoxycarbonyl, wherein the alkoxy moiety can be further substituted with a radical selected from the group consisting of hydroxy, methoxy, ethoxy, amino, mono- and di-C₁-C₄-alkylamino,

30

and

R⁸ represents hydrogen.

5 In another embodiment, the present invention relates to compounds of general formula (I), wherein

R¹ and R² represent hydrogen,

10 R³ represents fluoro, chloro, bromo, nitro, cyano, trifluoromethyl, methyl, methoxy or hydroxy,

R⁴ represents methyl or trifluoromethyl,

15 R⁵ represents methyl,

R⁶ represents cyano, methoxycarbonyl or ethoxycarbonyl,

R⁷ represents hydrogen, methyl or amino,

20 R⁸ and R⁹ represent hydrogen,

and

R¹⁰ represents fluoro, chloro, bromo, nitro, cyano, trifluoromethyl or methyl.

25

In another embodiment, the present invention relates to compounds according to general formula (I), wherein R⁴ is methyl.

30

In another embodiment, the present invention relates to compounds according to general formula (I), wherein R⁵ is methyl.

In another embodiment, the present invention relates to compounds according to general formula (I), wherein R⁶ is methoxycarbonyl or ethoxycarbonyl.

5 In another embodiment, the present invention relates to compounds according to general formula (I), wherein R⁷ is hydrogen, methyl or amino.

The compounds according to this invention can also be present in the form of their salts, hydrates and/or solvates.

10 Physiologically acceptable salts are preferred in the context of the present invention.

Physiologically acceptable salts according to the invention are non-toxic salts which in general are accessible by reaction of the compounds (I) with an inorganic or organic base or acid conventionally used for this purpose. Non-limiting examples of 15 pharmaceutically acceptable salts of compounds (I) include the alkali metal salts, e.g. lithium, potassium and sodium salts, the alkaline earth metal salts such as magnesium and calcium salts, the quaternary ammonium salts such as, for example, triethyl ammonium salts, acetates, benzene sulphonates, benzoates, dicarbonates, disulphates, ditartrates, borates, bromides, carbonates, chlorides, citrates, dihydrochlorides, 20 fumarates, gluconates, glutamates, hexyl resorcinates, hydrobromides, hydrochlorides, hydroxynaphthoates, iodides, isothionates, lactates, laurates, malates, maleates, mandelates, mesylates, methylbromides, methylnitrates, methylsulphates, nitrates, oleates, oxalates, palmitates, pantothenates, phosphates, diphosphates, 25 polygalacturonates, salicylates, stearates, sulphates, succinates, tartrates, tosylates, valerates, and other salts used for medicinal purposes.

Hydrates of the compounds of the invention or their salts are stoichiometric compositions of the compounds with water, such as for example hemi-, mono-, or dihydrates.

Solvates of the compounds of the invention or their salts are stoichiometric compositions of the compounds with solvents.

The present invention includes both the individual enantiomers or diastereomers and
5 the corresponding racemates or diastereomeric mixtures of the compounds according to the invention and their respective salts. In addition, all possible tautomeric forms of the compounds described above are included according to the present invention. The diastereomeric mixtures can be separated into the individual isomers by chromatographic processes. The racemates can be resolved into the respective
10 enantiomers either by chromatographic processes on chiral phases or by resolution.

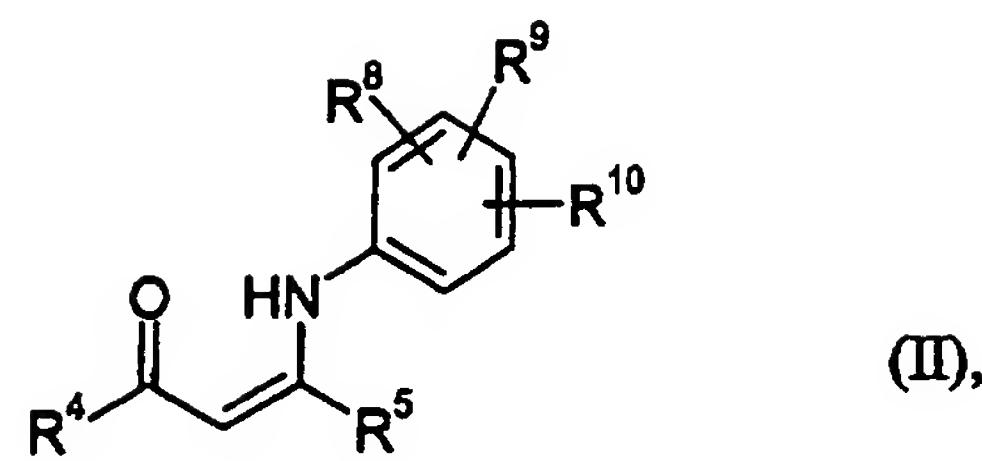
In the context of the present invention, the substituents, if not stated otherwise, in general have the following meaning:

15 Alkyl in general represents a straight-chain or branched hydrocarbon radical having 1 to 6, preferably 1 to 4 carbon atoms. Non-limiting examples include methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec.-butyl, tert.-butyl, pentyl, isopentyl, hexyl, isohexyl. The same applies to radicals such as alkoxy, alkylamino, alkoxycarbonyl and alkoxycarbonylamino.

20 Acyl or Alkanoyl in general represents a straight-chain or branched hydrocarbon radical having 1 to 6, preferably 1 to 4 carbon atoms which has a carbonyl function at the position of attachment. Non-limiting examples include formyl, acetyl, n-propionyl, n-butyryl, isobutyryl, pivaloyl, n-hexanoyl. The same applies to radicals such as
25 acylamino.

In another embodiment, the present invention relates to processes for synthesizing the compounds of general formula (I), characterized in that either

30 [A] compounds of the general formula (II)



wherein R⁴, R⁵, R⁸, R⁹ and R¹⁰ have the meaning described above,

5 are condensed in the presence of a base, in a three-component-reaction, with compounds of the general formulas (III) and (IV)



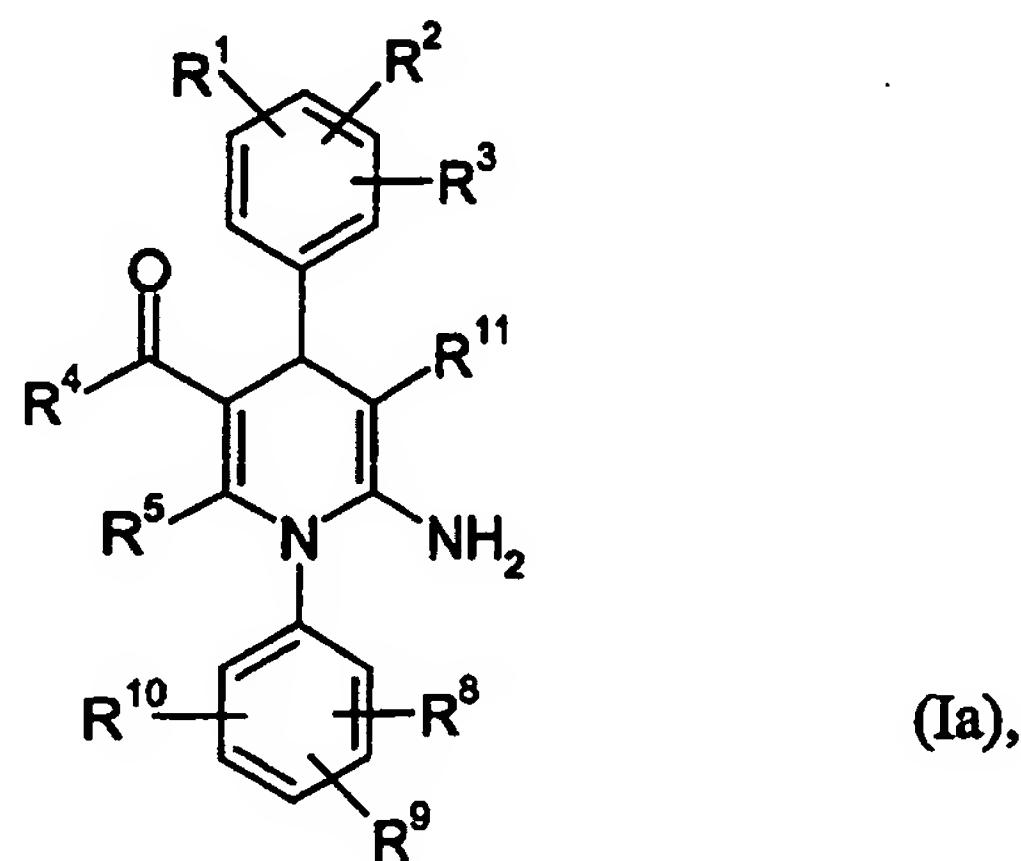
wherein R¹, R² and R³ have the meaning described above,

10

and

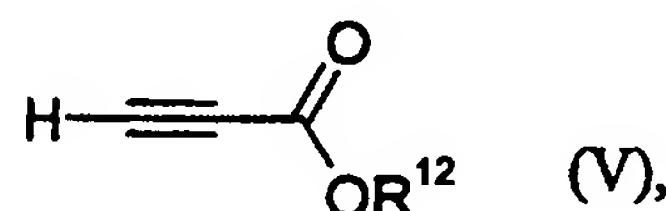
R¹¹ represents cyano or C₁-C₆-alkoxycarbonyl,

15 to give compounds of the general formula (Ia)



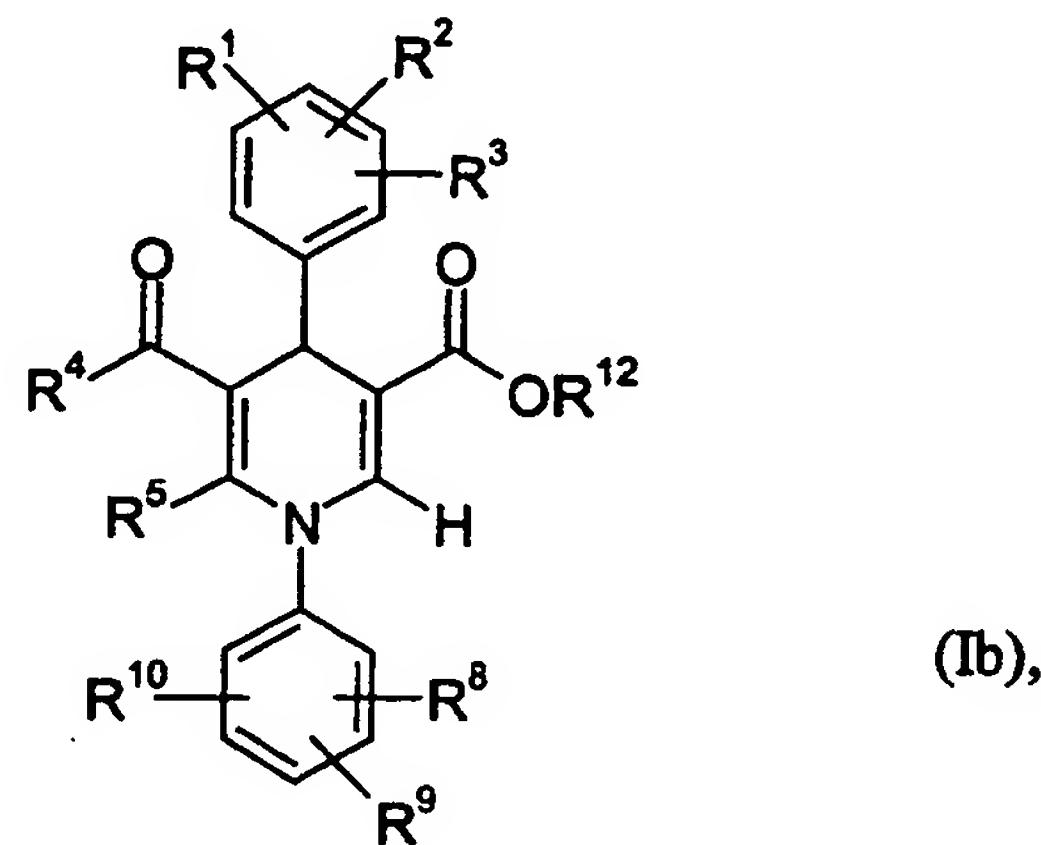
or

5 [B] compounds of the general formulas (II) and (III) are condensed in the presence of an acid, in a three-component-reaction, with compounds of the general formula (V)



10 wherein R^{12} represents $\text{C}_1\text{-C}_6$ -alkyl,

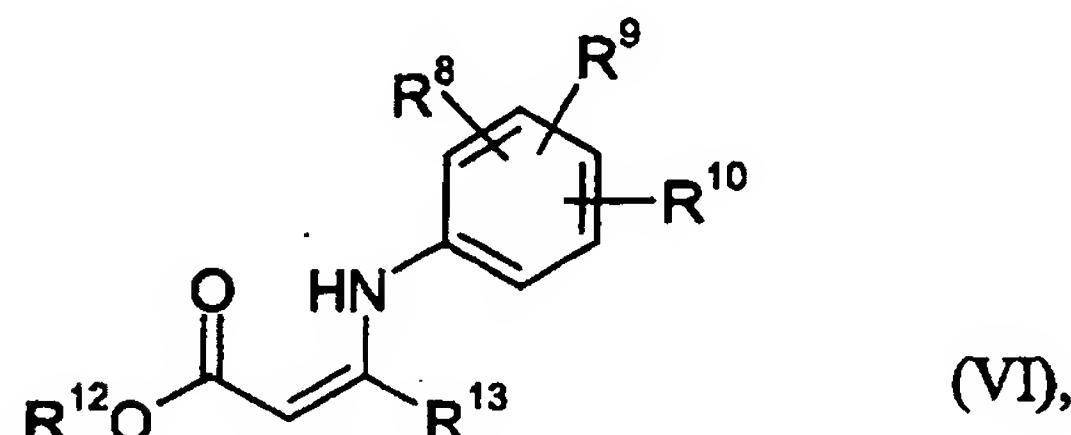
15 to give compounds of the general formula (Ib)



or

15

[C] compounds of the general formula (VI)



wherein R^8 , R^9 , R^{10} and R^{12} have the meaning described above,

and

5

R^{13} represents C_1 - C_4 -alkyl,

are condensed in the presence of an acid or a base, in a three-component-reaction, with compounds of the general formulas (III) and (VII)

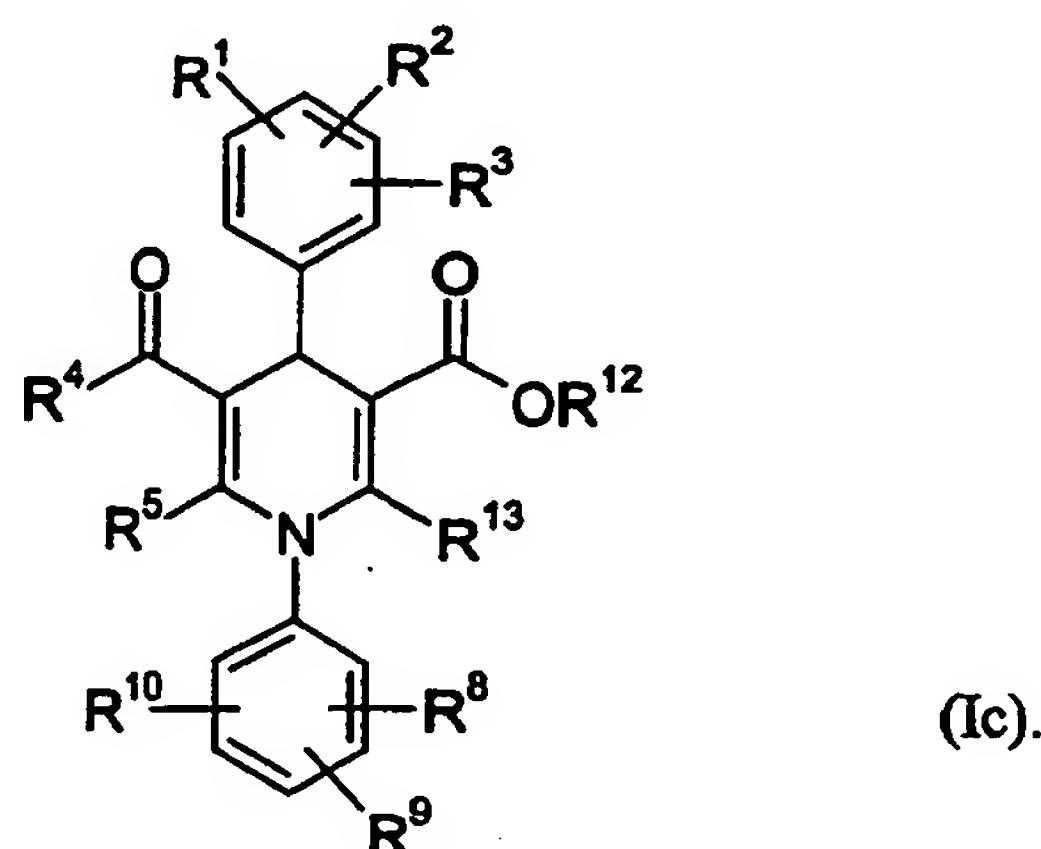
10



wherein R^4 and R^5 have the meaning described above,

15

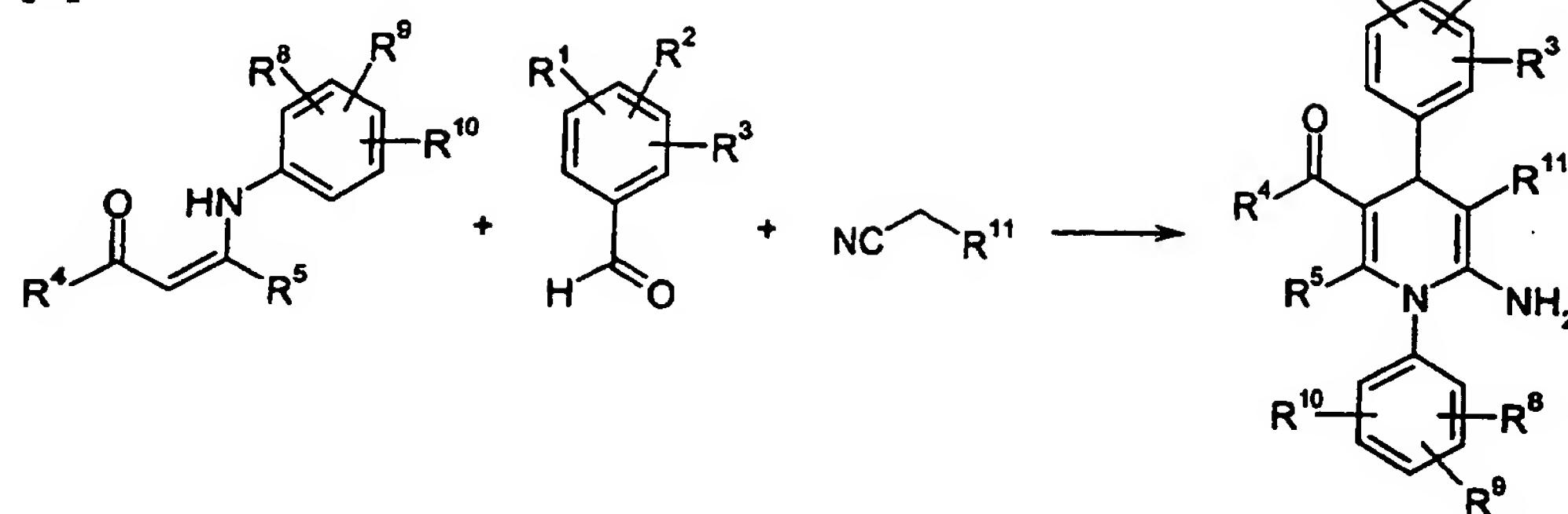
to give compounds of the general formula (Ic)



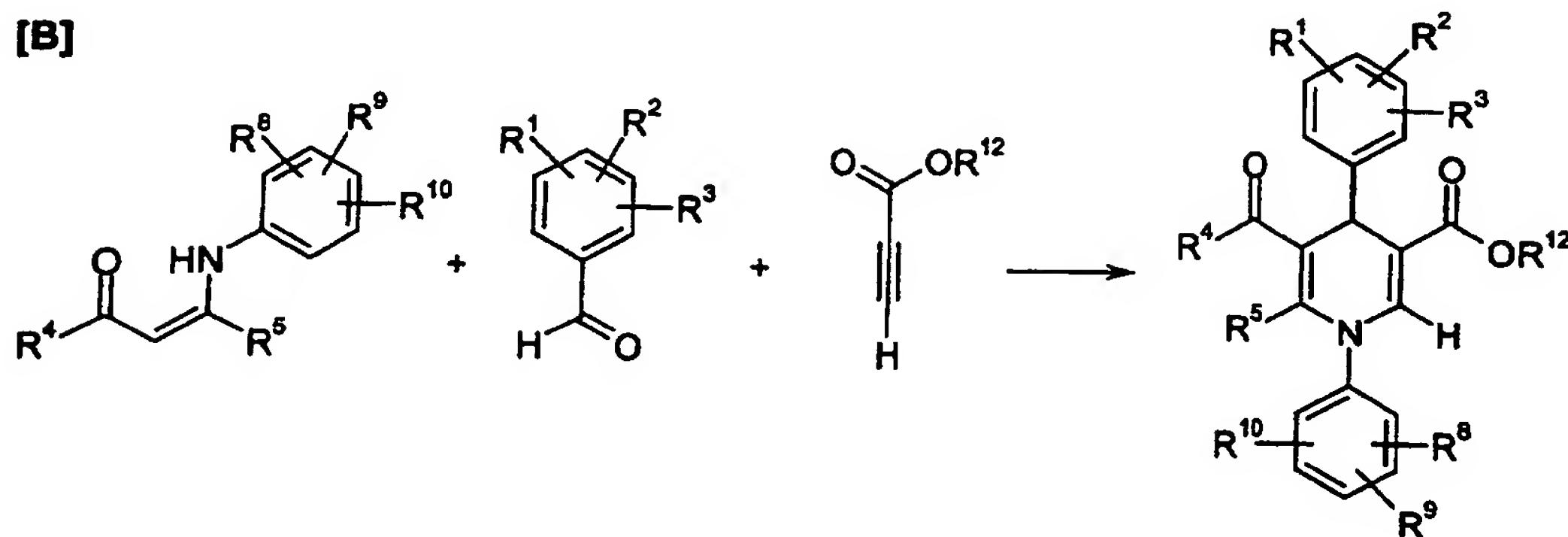
The processes can be illustrated by the following schemes [A] to [C]:

Scheme [A] to [C]

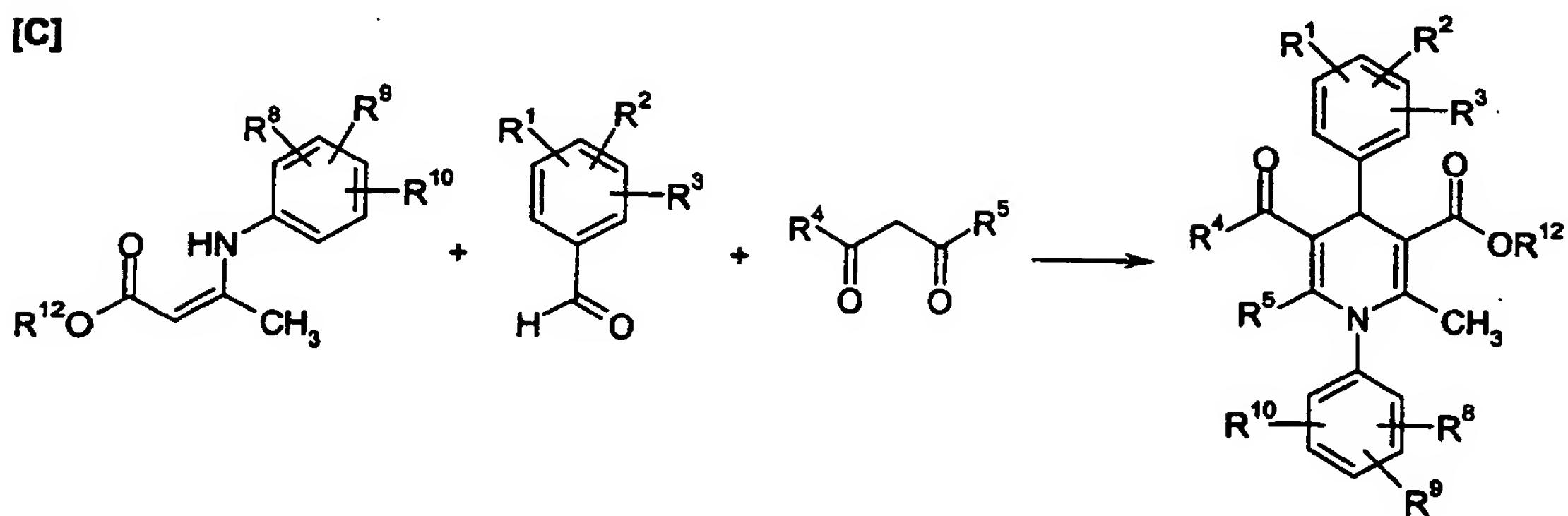
[A]



[B]



[C]



Suitable solvents for the processes [A] to [C] are generally customary organic solvents which do not change under the reaction conditions. These include ethers such as diethyl ether, diisopropyl ether, 1,2-dimethoxyethane, dioxan or tetrahydrofuran, ethylacetate, acetone, acetonitrile, dimethylsulfoxide, dimethylformamide, or alcohols such as methanol, ethanol, n-propanol, isopropanol, n-butanol or t-butanol, or hydrocarbons such as pentane, hexane, cyclohexane, benzene, toluene or xylene, or halogeno-hydro-

carbons such as dichloromethane, dichloroethane, trichloromethane or chlorobenzene. For process [B] and [C] also acetic acid can be employed as solvent. It is also possible to use mixtures of the above-mentioned solvents. Preferred for process [A] is ethanol or a mixture of n-propanol and dimethylsulfoxide. For process [B] and [C] acetic acid or diisopropyl ether are preferred.

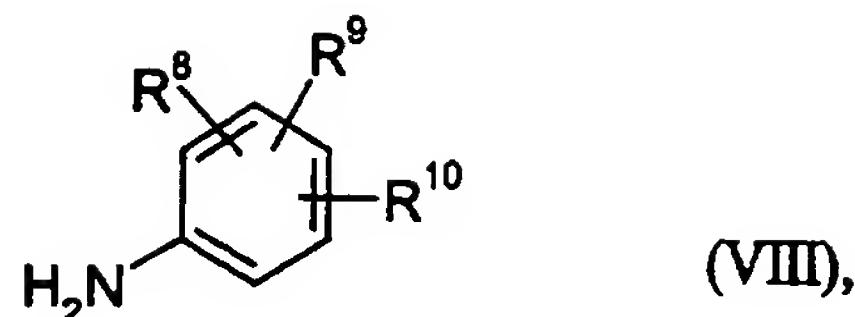
Suitable bases for process [A] and [C] are generally inorganic or organic bases. These preferably include cyclic amines, such as, for example, piperidine, morpholine, N-methylmorpholine, pyridine or 4-N,N-dimethylaminopyridine, or (C₁-C₄)-trialkylamines, such as, for example, triethylamine or diisopropylethylamine. Preference is given to piperidine. The base is employed in an amount from 0.1 mol to 10 mol, preferably from 1 mol to 3 mol, relative to 1 mol of the compound of the general formula (II).

Suitable acids for process [B] and [C] are generally inorganic or organic acids. These preferably include carboxylic acids, such as, for example acetic acid or trifluoroacetic acid, or sulfonic acids, such as, for example, methanesulfonic acid or p-toluenesulfonic acid. Preference for process [B] and [C] is given to acetic acid or trifluoroacetic acid. The acid is employed in an amount from 0.25 mol to 100 mol, relative to 1 mol of the compounds of the general formulas (V) and (VII), respectively.

The processes [A] to [C] are in general carried out in a temperature range from +20°C to +150°C, preferably from +60°C to +130°C.

The processes [A] to [C] are generally carried out at normal pressure. However, it is also possible to carry them out at elevated pressure or at reduced pressure (for example in a range from 0.5 to 5 bar).

The compounds of general formula (II) can be synthesized by reacting compounds of general formula (VII) with compounds of the general (VIII)



wherein R⁸, R⁹ and R¹⁰ have the meaning described above,

5 in the presence of an acid, such as acetic acid or p-toluenesulfonic acid, under water-removing conditions.

The compounds of general formula (VI) can be synthesized analogously.

10 The compounds of the general formulas (III), (IV), (V), (VII) and (VIII) are known per se, or they can be prepared by customary methods.

Surprisingly, the compounds of the present invention show human neutrophil elastase (HNE) inhibitory activity and are therefore suitable for the preparation of
15 medicaments for the treatment of diseases associated with HNE activity. They may thus provide an effective treatment of acute and chronic inflammatory processes, such as rheumatoid arthritis, atherosclerosis, and especially of acute and chronic pulmonary diseases, such as lung fibrosis, cystic fibrosis, pneumonia, acute respiratory distress syndrome (ARDS), in particular pulmonary emphysema, including smoking-induced
20 emphysema, and chronic obstructive pulmonary diseases (COPD). They may also provide an effective treatment of brain trauma, cancer and other conditions in which neutrophil participation is involved.

The compounds of formula (I) according to the invention can therefore be used as
25 active compound components for the production of medicaments. For this, they can be converted into the customary formulations such as tablets, coated tablets, aerosols, pills, granules, syrups, emulsions, suspensions and solutions in a known manner using inert, non-toxic, pharmaceutically suitable excipients or solvents. Preferably,

the compounds according to the invention are used here in an amount such that their concentration in the total mixture is approximately 0.5% to approximately 90% by weight, the concentration, *inter alia*, being dependent on the corresponding indication of the medicament.

5

The above mentioned formulations are produced, for example, by extending the active compounds with solvents and/or excipients having the above properties, where, if appropriate, additionally emulsifiers or dispersants and, in the case of water as the solvent, alternatively an organic solvent, have to be added.

10

Administration is carried out in a customary manner, preferably orally, transdermally or parenterally, for example perlingually, buccally, intravenously, nasally, rectally or by inhalation.

15

For human use, in the case of oral administration, it is recommendable to administer doses of from 0.001 to 50 mg/kg, preferably of 0.01 mg/kg to 20 mg/kg. In the case of parenteral administration, such as, for example, intravenously or via mucous membranes nasally, buccally or inhalationally, it is recommendable to use doses of 0.001 mg/kg to 0.5 mg/kg.

20

In spite of this, if appropriate, it may be necessary to depart from the amounts mentioned above, namely depending on the body weight or the type of administration route, on the individual response towards the medicament, the manner of its formulation and the time or interval at which administration takes place. Thus, in some cases it may be sufficient to manage with less than the above mentioned minimum amount, while in other cases the upper limit mentioned must be exceeded. In the case of the administration of relatively large amounts, it may be recommendable to divide these into several individual doses over the course of the day.

30

The potential of the compounds of the invention to inhibit neutrophil elastase activity may be demonstrated, for example, using the following assays:

I. In vitro assays of human neutrophil elastase (HNE)

5

Assay contents

assay buffer: 0.1 M HEPES-NaOH buffer pH 7.4, 0.5 M NaCl, 0.1% (w/v) bovine serum albumin;

10 suitable concentration (see below) of HNE (18 U/mg lyophil., #20927.01, SERVA Electrophoresis GmbH, Heidelberg, Germany) in assay buffer;

suitable concentration (see below) of substrate in assay buffer;

suitable concentration of test compounds diluted with assay buffer from a 10 mM stock solution in DMSO.

15

Example A

In vitro inhibition of HNE using a fluorogenic peptide substrate (continuous read-out signal, 384 MTP assay format):

20

In this protocol, the elastase substrate MeOSuc-Ala-Ala-Pro-Val-AMC (#324740, Calbiochem-Novabiochem Corporation, Merck KgaA, Darmstadt, Germany) is used. The test solution is prepared by mixing 10 μ l of test compound dilution, 20 μ l of HNE enzyme dilution (final concentration 8 - 0.4 μ U/ml, routinely 2.1 μ U/ml) and 25 20 μ l of substrate dilution (final concentration 1 mM - 1 μ M, routinely 20 μ M), respectively. The solution is incubated for 0 - 2 hrs at 37°C (routinely one hour). The fluorescence of the liberated AMC due to the enzymatic reaction is measured at 37°C (TECAN spectra fluor plus plate reader). The rate of increase of the fluorescence (ex. 395 nm, em. 460 nm) is proportional to elastase activity. IC₅₀ values are determined 30 by RFU-versus-[I] plots. K_m and K_{m(app.)} values are determined by Lineweaver-Burk plots and converted to K_i values by Dixon plots.

The preparation examples had IC₅₀ values within the range of 20 nM - 20 μ M in this assay.

5 **Example B**

In vitro inhibition of HNE using a fluorogenic, unsoluble elastin substrate (discontinuous read-out signal, 96 MTP assay format)

10 In this protocol the elastase substrate elastin-fluorescein (#100620, ICN Biomedicals GmbH, Eschwege, Germany) is used. The test solution is prepared by mixing 3 μ l of test compound dilution, 77 μ l of HNE enzyme dilution (final concentration 0.22 U/ml - 2.2 mU/ml, routinely 21.7 μ U/ml) and 80 μ l substrate suspension (final concentration 2 mg/ml). The suspension is incubated for 0 - 16 hrs at 37°C (routinely 15 four hours) under slightly shaking conditions. To stop the enzymatic reaction, 160 μ l of 0.1 M acetic acid are added to the test solution (final concentration 50 mM). The polymeric elastin-fluorescein is pulled down by centrifugation (Eppendorf 5804 centrifuge, 3.000 rpm, 10 min). The supernatant is transferred into a new MTP and the fluorescence of the liberated peptide fluorescein due to the enzymatic reaction is 20 measured (BMG Fluostar plate reader). The rate of fluorescence (ex. 490 nm, em. 520 nm) is proportional to elastase activity. IC₅₀ values are determined by RFU-versus-[I] plots.

II. **In vitro PMN elastolysis assay**

25 This assay is used to determine the elastolytic potential of human polymorphonuclear cells (PMNs) and assess the proportion of degradation due to neutrophil elastase [cf. Z.W. She et al., Am. J. Respir. Cell. Mol. Biol. 9, 386-392 (1993)].

30 Tritiated elastin, in suspension, is coated on to a 96 well plate at 10 μ g per well. Test and reference [ZD-0892 (J. Med. Chem. 40, 1876-1885, 3173-3181 (1997), WO
LeA 35 748

95/21855) and α 1 protease inhibitor (α 1PI)] compounds are added to the wells at the appropriate concentrations. Human PMNs are separated from peripheral venous blood of healthy donors and resuspended in culture media. The neutrophils are added to the coated wells at concentrations ranging between 1×10^6 to 1×10^5 cells per well. Porcine pancreatic elastase (1.3 μ M) is used as a positive control for the assay, and α 1PI (1.2 μ M) is used as the positive inhibitor of neutrophil elastase. The cellular control is PMNs without compound at each appropriate cell density. The cells plus compounds are incubated in a humidified incubator at 37°C for 4 hours. The plates are centrifuged to allow the harvest of cell supernatant only. The supernatant is transferred in 75 μ l volumes to corresponding wells of a 96 well Lumaplate™ (solid scintillant containing plates). The plates are dried until no liquid is visible in the wells and read in a beta counter for 3 minutes per well.

Elastolysis of the 3 H-elastin results in an increase in counts in the supernatant. An inhibition of this elastolysis shows a decrease, from the cellular control, of tritium in the supernatant. α 1PI gave $83.46 \pm 3.97\%$ (mean \pm s.e.m.) inhibition at 1.2 μ M ($n = 3$ different donors at 3.6×10^5 cells per well). IC₅₀ values were obtained for the reference compound ZD-0892 of 45.50 ± 7.75 nM (mean \pm s.e.m.) ($n = 2$ different donors at 3.6×10^5 cells per well).

Given that ZD-0892 is a selective inhibitor of PMN elastase along with the data from α 1PI inhibition, these results indicate that the majority of elastin degradation by PMNs is due to the release of neutrophil elastase, and not to another elastolytic enzyme such as matrix metalloproteases (MMPs). The compounds of this invention were evaluated for their inhibitory activity in this HNE-dependent model of neutrophil elastolysis.

III. In vivo model of acute lung injury in the rat

Instillation of human neutrophil elastase (HNE) into rat lung causes acute lung damage. The extent of this injury can be assessed by measuring lung haemorrhage.

Rats are anaesthetised with Hypnorm/Hypnovel/water and instilled with HNE or saline delivered by microsprayer into the lungs. Test compounds are administered by intravenous injection, by oral gavage or by inhalation at set times prior to the administration of HNE. Sixty minutes after the administration of elastase animals are killed by an anaesthetic overdose (sodium pentobarbitone) and the lungs lavaged with 2 ml heparinised phosphate buffered saline (PBS). Bronchoalveolar lavage (BAL) volume is recorded and the samples kept on ice. Each BAL sample is centrifuged at 900 r.p.m. for 10 minutes at 4-10°C. The supernatant is discarded and the cell pellet resuspended in PBS and the sample spun down again. The supernatant is again discarded and the cell pellet resuspended in 1 ml 0.1% cetyltrimethylammonium bromide (CTAB) / PBS to lyse the cells. Samples are frozen until blood content is assayed. Prior to the haemorrhage assay the samples are defrosted and mixed. 100 µl of each sample are placed into a separate well of a 96 well flat-bottomed plate. All samples are tested in duplicate. 100 µl 0.1% CTAB/PBS is included as a blank. The absorbance of the well contents is measured at 415 nm using a spectrophotometer. A standard curve is constructed by measuring the OD at 415 nm of different concentrations of blood in 0.1% CTAB/PBS. Blood content values are calculated by comparison to the standard curve (included in each plate) and normalised for the volume of BAL fluid retrieved.

The compounds of this invention were evaluated intravenously, orally or by inhalation for their inhibitory activity in this model of HNE-induced haemorrhage in the rat.

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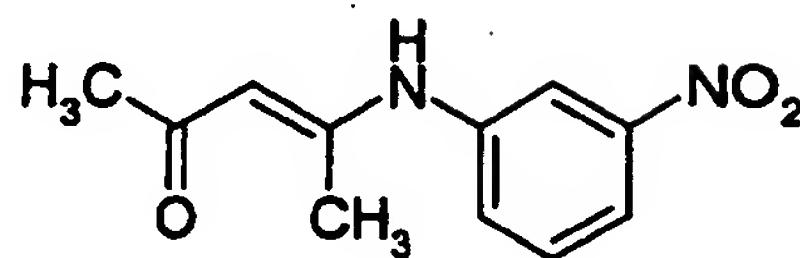
Abbreviations

c	=	concentration
DMSO	=	dimethylsulfoxide
30	NMR	= nuclear magnetic resonance spectroscopy

Starting Materials

Example 1A

5 4-[(3-Nitrophenyl)amino]-3-penten-2-one



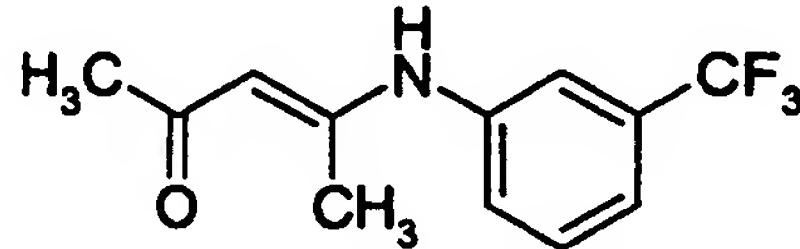
36.24 g (362 mmol) Acetylacetone, 10.00 g (72 mmol) 3-nitroanilin, and 1.25 g
10 (7.2 mmol) 4-toluenesulfonic acid are dissolved in 100 ml toluene. The reaction
mixture is refluxed overnight with a Dean-Stark trap to remove water. After cooling
down to room temperature, the solvent is removed *in vacuo* and the residue is
purified by column chromatography on silica with eluent dichloromethane.

Yield: 12.0 g (75%)

15 $^1\text{H-NMR}$ (400 MHz, DMSO): $\delta = 2,0$ (s, 3H); 2,1 (s, 3H); 5,4 (s, 1H); 7,7 (m, 2H);
8,0 (m, 2H); 12,5 (s, 1H) ppm.

Example 2A

20 4-{[3-(Trifluoromethyl)phenyl]amino}-3-penten-2-one



15.53 g (155 mmol) Acetylacetone, 5.00 g (31 mmol) 3-trifluoromethylanilin, and
0.53 g (3.1 mmol) 4-toluenesulfonic acid are dissolved in 50 ml toluene. The reaction
25 mixture is refluxed overnight with a Dean-Stark trap to remove water. After cooling
down to room temperature, the solvent is removed *in vacuo* and the residue is

purified by column chromatography on silica with cyclohexane/ethylacetate mixtures as eluent.

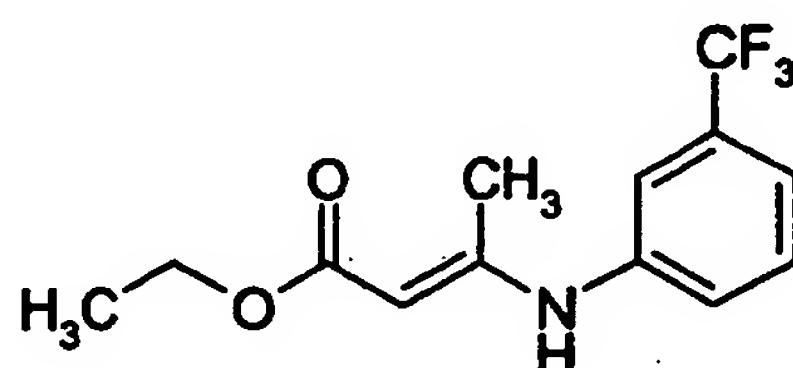
Yield: 5.46 g (72%)

¹H-NMR (200 MHz, DMSO): δ = 2,0 (s, 3H); 2,1 (s, 3H); 5,3 (s, 1H); 7,5 (m, 4H);
5 12,5 (s, 1H) ppm.

Example 3A

Ethyl (2E)-3-{{[3-(trifluoromethyl)phenyl]amino}-2-butenoate

10



15 4.0 g (31 mmol) Ethyl 3-oxobutanoate, 5.0 g (31 mmol) 3-trifluoromethylanilin, and 1.86 g (31 mmol) acetic acid are dissolved in 50 ml toluene. The reaction mixture is refluxed overnight with a Dean-Stark trap to remove water. After cooling down to room temperature, the solvent is removed *in vacuo* and the residue is purified by column chromatography on silica with cyclohexane/ethylacetate mixtures as eluent.

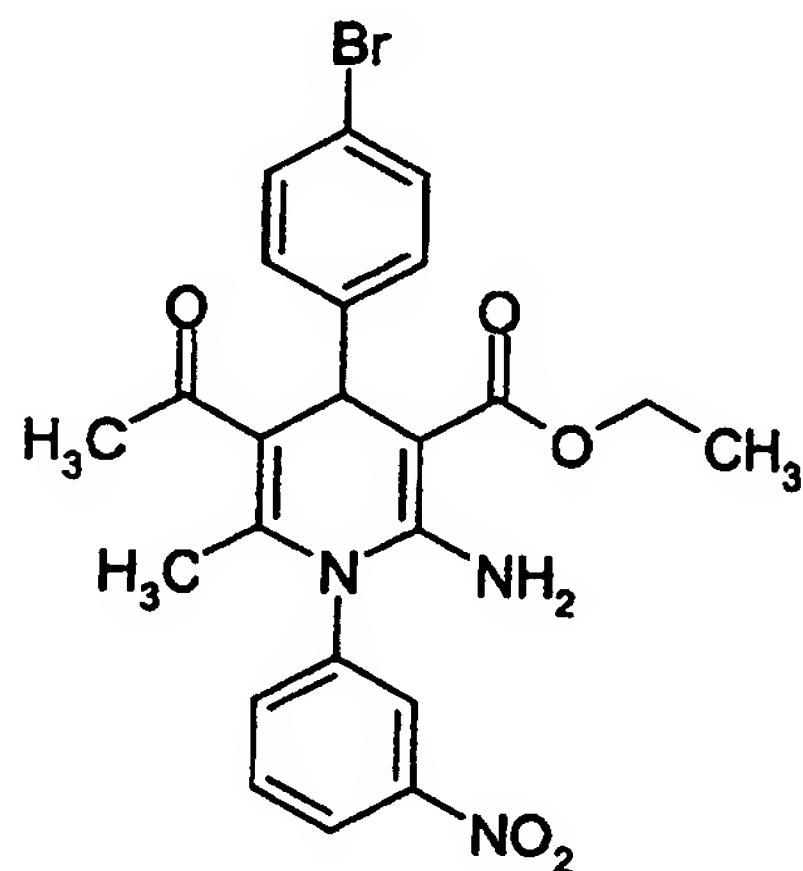
Yield: 2.28 g (27%)

¹H-NMR (300 MHz, DMSO): δ = 1,2 (t, 3H); 2,0 (s, 3H); 4,1 (q, 2H); 4,8 (s, 1H);
20 7,5 (m, 4H); 10,4 (s, 1H) ppm.

Preparation Examples

Example 1

5 (\pm)-Ethyl 5-acetyl-2-amino-4-(4-bromophenyl)-6-methyl-1-(3-nitrophenyl)-1,4-dihydro-3-pyridinecarboxylate



10 4.8 g (21.8 mmol) of Example 1A are dissolved in 30 ml ethanol, 4.0 g (21.8 mmol) 4-bromobenzaldehyde, 2.47 g (21.8 mmol) ethyl cyanoacetate, and 3.71 g (43.6 mmol) piperidine are added. The reaction mixture is stirred under reflux overnight. After cooling down to room temperature, the solvent is removed *in vacuo* and the residue is purified by column chromatography on silica with eluent dichloromethane.

15 Yield: 1.8 g (17%)

20 $^1\text{H-NMR}$ (300 MHz, DMSO): δ = 1,2 (t, 3H); 1,9 (s, 3H); 2,2 (s, 3H); 4,0 (m, 2H); 4,9 (s, 1H); 6,8 (br.s, 2H); 7,3 (m, 2H); 7,5 (m, 2H); 7,8 (m, 2H); 8,2 (m, 1H); 8,4 (m, 1H) ppm.

Example 2

20

20 (-)-Ethyl 5-acetyl-2-amino-4-(4-bromophenyl)-6-methyl-1-(3-nitrophenyl)-1,4-dihydro-3-pyridinecarboxylate

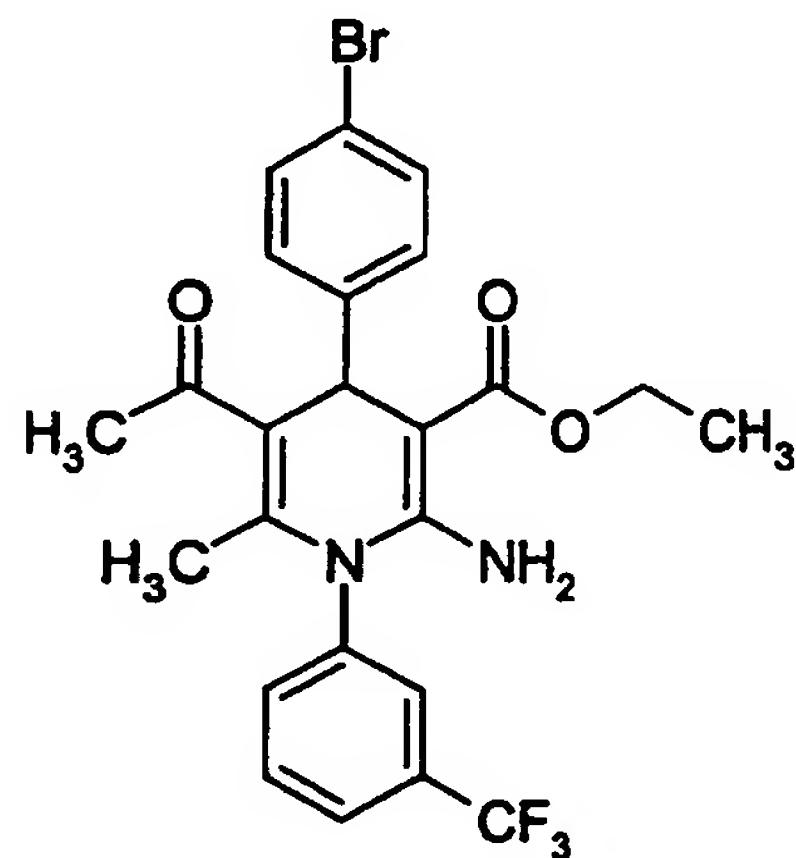
The enantiomers of Example 1 are separated by chiral HPLC [silane modified poly-(N-methacryloyl-L-leucin-1-menthylamide) fixed on silica; 250 x 20 mm column] with iso-hexane/ethylacetate 4/1 as eluent (20 ml/min).

$[\alpha]^{20} = -97.6^\circ$ ($\lambda = 589$ nm, methanol, $c = 456.5$ mg / 100 ml)

5 $^1\text{H-NMR}$ identical with Example 1.

Example 3

10 (\pm) -Ethyl 5-acetyl-2-amino-4-(4-bromophenyl)-6-methyl-1-[3-(trifluoromethyl)-phenyl]-1,4-dihydro-3-pyridinecarboxylate



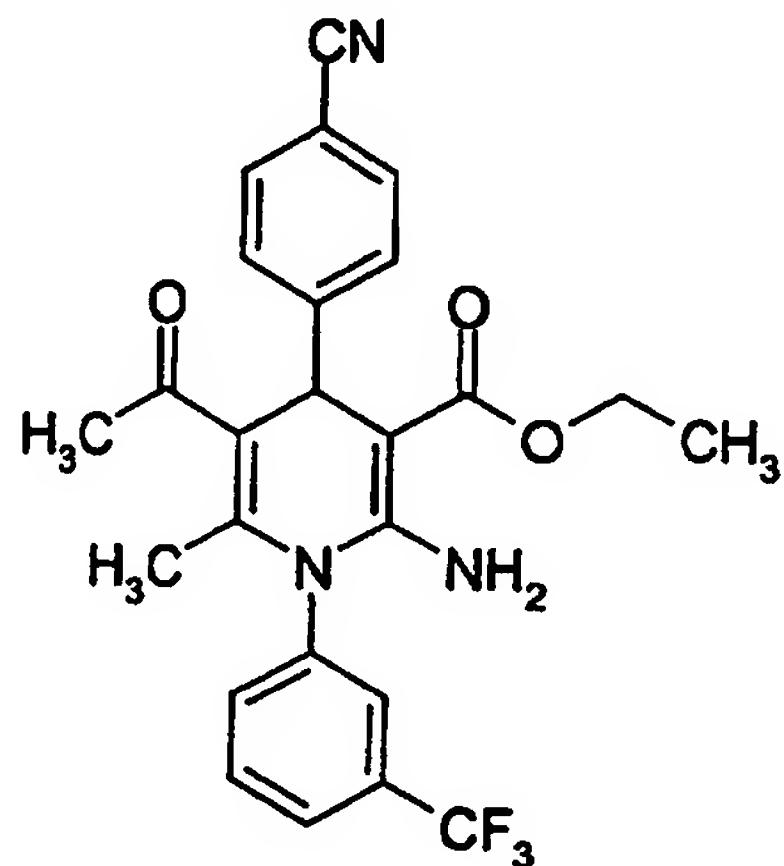
15 150 mg (0.62 mmol) of Example 2A are dissolved in 2 ml ethanol, 114 mg (0.62 mmol) 4-bromobenzaldehyde, 70 mg (0.62 mmol) ethyl cyanoacetate, and 105 mg (1.23 mmol) piperidine are added. The reaction mixture is stirred under reflux overnight. After cooling down to room temperature, the solvent is removed *in vacuo* and the residue is purified by column chromatography on silica with eluent dichloromethane.

20 Yield: 43 mg (13%)

$^1\text{H-NMR}$ (300 MHz, DMSO): $\delta = 1,2$ (t, 3H); 1,8 (s, 3H); 2,2 (s, 3H); 4,0 (m, 2H); 4,9 (s, 1H); 6,7 (br.s, 2H); 7,3 (m, 2H); 7,5 (m, 2H); 7,7 (m, 1H); 7,8 (m, 1H); 7,8 (m, 1H); 7,9 (m, 1H) ppm.

Example 4

(\pm)-Ethyl 5-acetyl-2-amino-4-(4-cyanophenyl)-6-methyl-1-[3-(trifluoromethyl)-phenyl]-1,4-dihydro-3-pyridinecarboxylate



5

100 mg (0.41 mmol) of Example 2A are dissolved in 2 ml ethanol, 54 mg (0.41 mmol) 4-cyanobenzaldehyde, 47 mg (0.41 mmol) ethyl cyanoacetate, and 70 mg (0.82 mmol) piperidine are added. The reaction mixture is stirred under reflux overnight. After cooling down to room temperature, the solvent is removed *in vacuo* and the residue is purified by column chromatography on silica with eluent dichloromethane.

10

Yield: 26 mg (14%)

15 $^1\text{H-NMR}$ (400 MHz, DMSO): δ = 1,2 (t, 3H); 1,8 (s, 3H); 2,2 (s, 3H); 4,0 (m, 2H); 5,0 (s, 1H); 6,7 (br.s, 2H); 7,5 (m, 2H); 7,7 (m, 1H); 7,8 (m, 4H); 7,9 (m, 1H) ppm.

Example 5 and Example 6

20 (+) and (-)-Ethyl 5-acetyl-2-amino-4-(4-cyanophenyl)-6-methyl-1-[3-(trifluoro-methyl)phenyl]-1,4-dihydro-3-pyridinecarboxylate

The enantiomers of Example 4 are separated by chiral HPLC [silane modified poly-(N-methacryloyl-L-leucin-l-menthylamide) fixed on silica; 250 x 20 mm column] with iso-hexane/ethylacetate 4/1 as eluent (20 ml/min).

(+)-Enantiomer (Example 5):

5 $[\alpha]^{20} = +88.4^\circ$ ($\lambda = 589$ nm, methanol, $c = 453.5$ mg / 100ml)

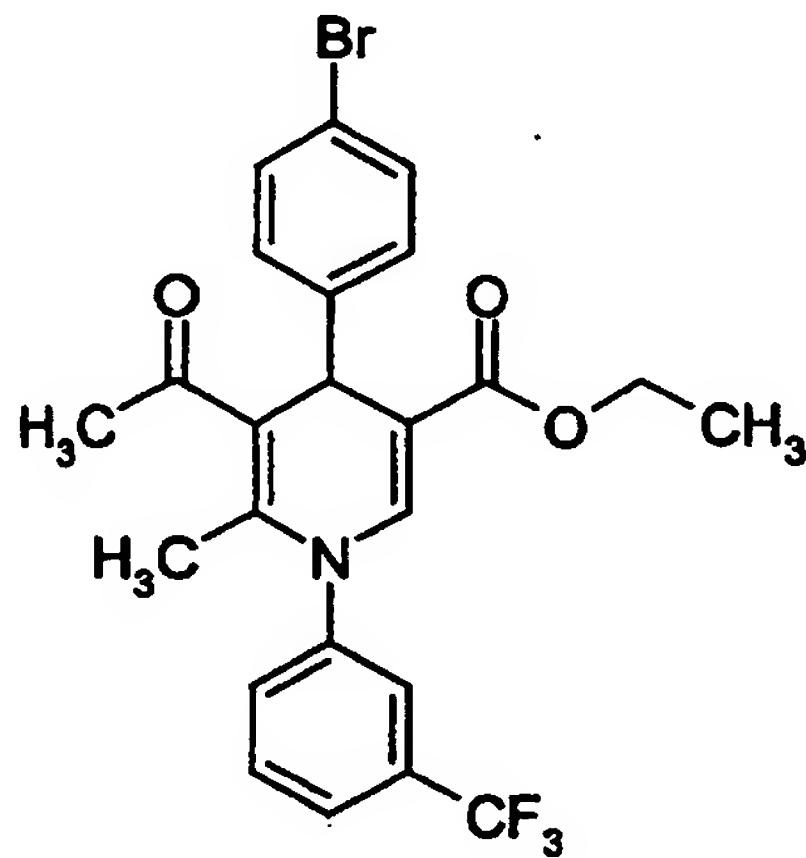
(-)-Enantiomer (Example 6):

$[\alpha]^{20} = -91.2^\circ$ ($\lambda = 589$ nm, methanol, $c = 471.5$ mg / 100ml)

$^1\text{H-NMRs}$ for Example 5 and 6 identical with Example 4.

10 Example 7

(\pm)-Ethyl 5-acetyl-4-(4-bromophenyl)-6-methyl-1-[3-(trifluoromethyl)phenyl]-1,4-dihydro-3-pyridinecarboxylate



15

150 mg (0.62 mmol) of Example 2A are dissolved in 2 ml acetic acid, 114 mg (0.62 mmol) 4-bromobenzaldehyde, and 60 mg (0.62 mmol) ethyl propiolate are added. The reaction mixture is stirred under reflux overnight. After cooling down to room temperature, the solvent is removed *in vacuo* and the residue is purified by column chromatography on silica with eluent dichloromethane.

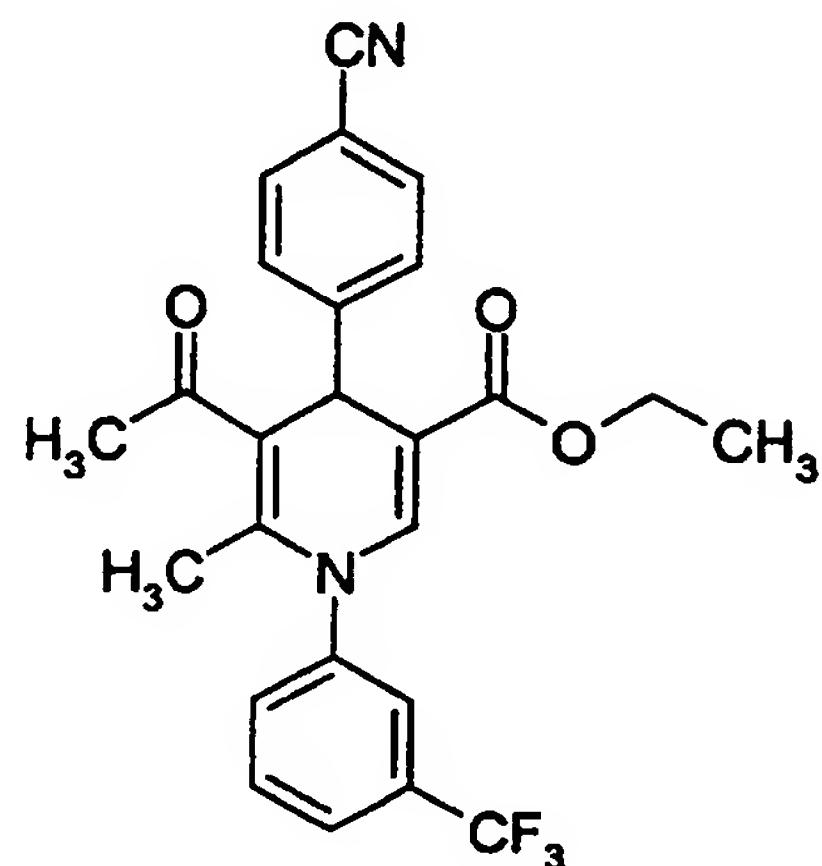
20

Yield: 56 mg (18%)

$^1\text{H-NMR}$ (300 MHz, DMSO): $\delta = 1,1$ (t, 3H); 1,9 (s, 3H); 2,2 (s, 3H); 4,1 (m, 2H); 5,0 (s, 1H); 7,3 (m, 3H); 7,5 (m, 2H); 7,7 (m, 2H); 7,8 (m, 1H); 7,9 (s, 1H) ppm.

Example 8

(\pm)-Ethyl 5-acetyl-4-(4-cyanophenyl)-6-methyl-1-[3-(trifluoromethyl)phenyl]-1,4-di-
5 hydro-3-pyridinecarboxylate



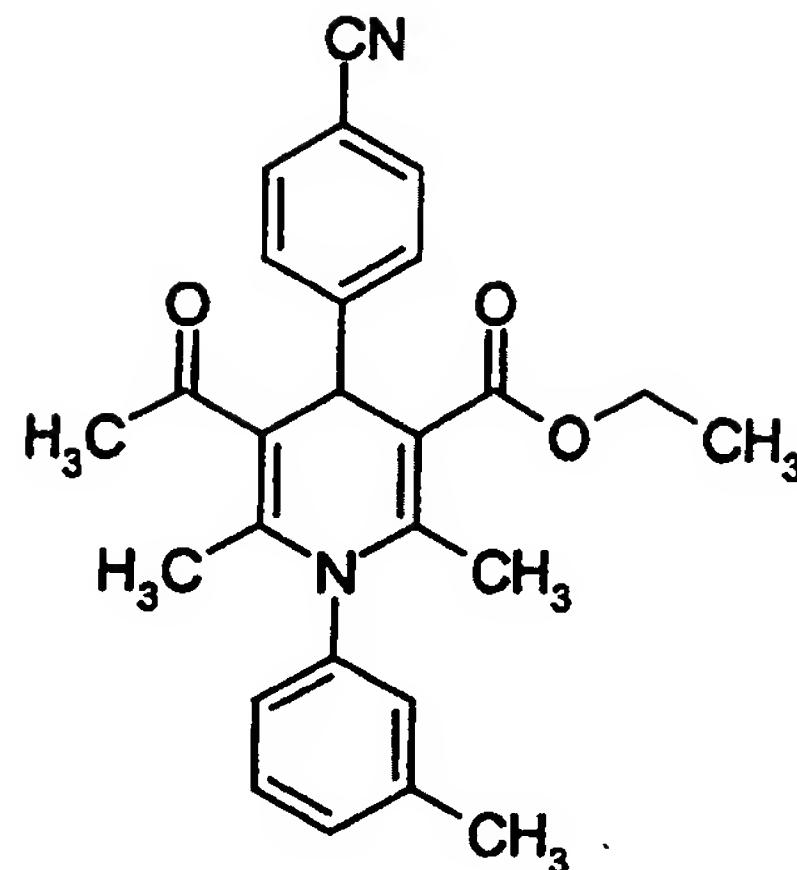
100 mg (0.41 mmol) of Example 2A are dissolved in 2 ml acetic acid, 54 mg (0.41 mmol) 4-cyanobenzaldehyde, and 40 mg (0.41 mmol) ethyl propiolate are added. The reaction mixture is stirred under reflux overnight. After cooling down to room temperature, the solvent is removed *in vacuo* and the residue is purified by column chromatography on silica with eluent dichloromethane.

Yield: 20 mg (11%)

¹H-NMR (300 MHz, DMSO): δ = 1,1 (t, 3H); 2,0 (s, 3H); 2,2 (s, 3H); 4,1 (m, 2H);
5,1 (s, 1H); 7,3 (s, 1H); 7,6 (m, 2H); 7,8 (m, 4H); 7,8 (m, 1H); 8,0 (s, 1H) ppm.

Example 9

(\pm)-Ethyl 5-acetyl-4-(4-cyanophenyl)-2,6-dimethyl-1-(3-methylphenyl)-1,4-dihydro-
3-pyridinecarboxylate



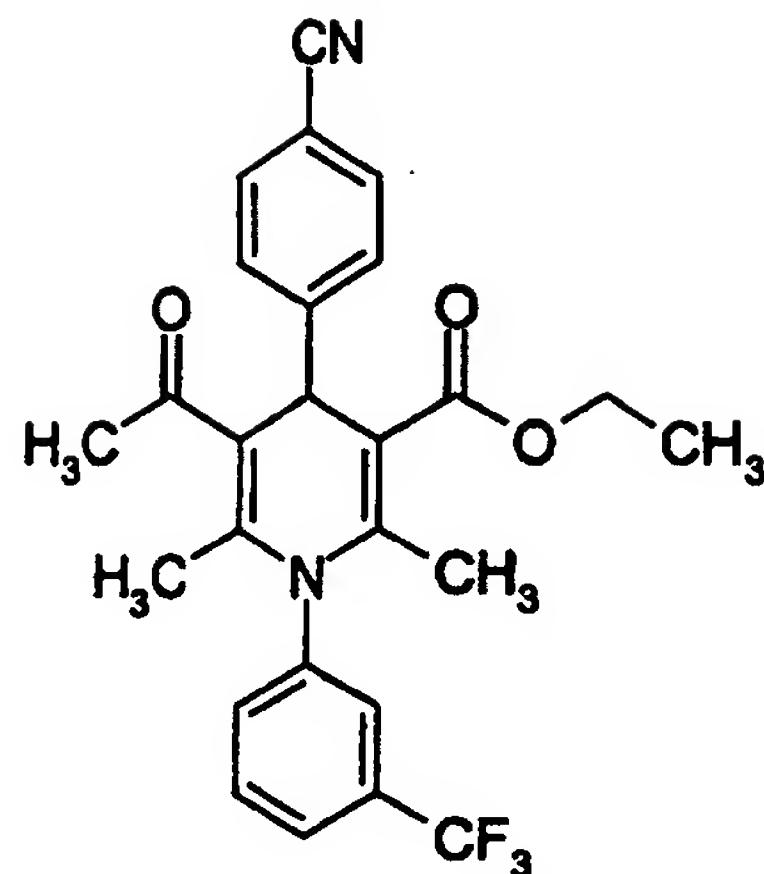
100 mg (0.46 mmol) Ethyl (2E)-3-{[3-(methyl)phenyl]amino}-2-butenoate, 75 mg (0.57 mmol) 4-cyanobenzaldehyde, 38 mg (0.38 mmol) 2,4-pentanedione, and 87 mg (0.76 mmol) trifluoroacetic acid are dissolved in 2 ml diisopropyl ether. The reaction mixture is stirred under reflux overnight. After cooling down to room temperature, the solvent is removed *in vacuo* and the residue is purified by preparative HPLC.

Yield: 11 mg (7%)

¹H-NMR (300 MHz, DMSO): δ = 1.2 (t, 3H); 2.0 (s, 3H); 2.0 (s, 3H); 2.2 (s, 3H); 2.4 (s, 3H); 4.1 (q, 2H); 5.1 (s, 1H); 7.0 (m, 2H); 7.3 (m, 1H); 7.4 (m, 1H); 7.5 (m, 2H); 7.8 (m, 2H) ppm.

Example 10

15 (±)-Ethyl 5-acetyl-4-(4-cyanophenyl)-2,6-dimethyl-1-[3-(trifluoromethyl)phenyl]-1,4-dihydro-3-pyridinecarboxylate



100 mg (0.37 mmol) of Example 3A, 60 mg (0.46 mmol) 4-cyanobenzaldehyde,
31 mg (0.31 mmol) 2,4-pentanedione, and 70 mg (0.61 mmol) trifluoroacetic acid are
dissolved in 2 ml diisopropyl ether. The reaction mixture is stirred under reflux
overnight. After cooling down to room temperature, the solvent is removed *in vacuo*
and the residue is purified by preparative HPLC.

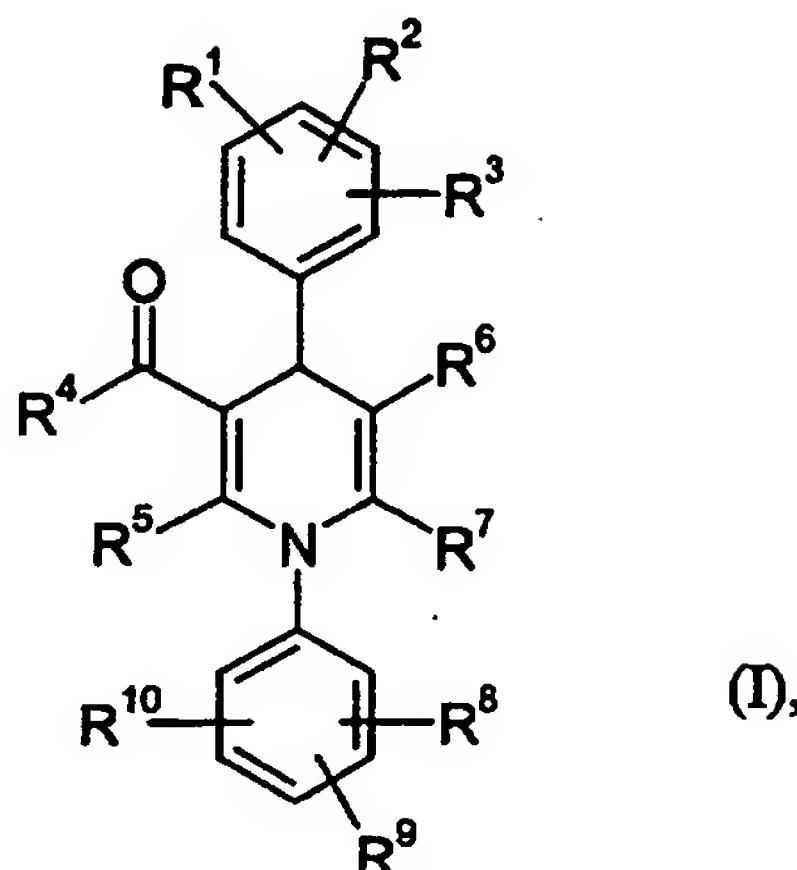
Yield: 7 mg (5%)

¹H-NMR (300 MHz, DMSO): δ = 1.2 (t, 3H); 1.9 (s, 3H); 2.0 (s, 3H); 2.3 (s, 3H); 4.1 (q, 2H); 5.1 (s, 1H); 7.5 (m, 2H); 7.6 (m, 1H); 7.7 (m, 1H); 7.8 (m, 3H); 7.9 (m, 1H) ppm.

It will of course be understood that the present invention has been described above purely by way of example, and that modifications of detail can be made within the scope of this invention.

We claim

1. Compounds of the general formula (I)



5

wherein

R^1, R^2, R^3, R^8, R^9 and R^{10} independently from each other represent hydrogen, halogen, nitro, cyano, trifluoromethyl, C_1 - C_6 -alkyl, C_1 - C_6 -alkanoyl, hydroxy, C_1 - C_6 -alkoxy, trifluoromethoxy, amino, mono- or di- C_1 - C_6 -alkylamino, C_1 - C_6 -acylamino, C_1 - C_6 -alkoxycarbonylamino, carboxyl, C_1 - C_6 -alkoxycarbonyl or phenyl, wherein C_1 - C_6 -alkyl, C_1 - C_6 -alkanoyl, C_1 - C_6 -alkoxy, mono- or di- C_1 - C_6 -alkylamino and C_1 - C_6 -acylamino can be further substituted with one to three identical or different radicals selected from the group consisting of hydroxy, C_1 - C_4 -alkoxy, amino, mono- and di- C_1 - C_4 -alkylamino,

15 R^4 represents C_1 - C_6 -alkyl, trifluoromethyl or phenyl,

20 R^5 represents C_1 - C_4 -alkyl,

R^6 represents cyano, carboxyl or C_1 - C_6 -alkoxycarbonyl, wherein the alkoxy moiety can be further substituted with a radical selected from

the group consisting of hydroxy, C₁-C₄-alkoxy, amino, mono- and di-C₁-C₄-alkylamino,

and

5

R⁷ represents hydrogen, C₁-C₄-alkyl or amino.

2. Compounds of general formula (I) according to claim 1, wherein

10

R¹ represents hydrogen,

R², R³, R⁹ and R¹⁰ independently from each other represent hydrogen, halogen, nitro, cyano, trifluoromethyl, C₁-C₄-alkyl, C₁-C₄-alkanoyl, hydroxy, C₁-C₄-alkoxy, trifluoromethoxy, amino, C₁-C₄-dialkylamino, 15 C₁-C₄-acylamino, methoxy-carbonylamino, tert.-butoxycarbonyl-amino, carboxyl, methoxycarbonyl or ethoxycarbonyl, wherein C₁-C₄-alkyl, C₁-C₄-alkanoyl, C₁-C₄-alkoxy, C₁-C₄-dialkylamino and C₁-C₄-acylamino can be further substituted with one to two identical or different radicals selected from the group consisting of hydroxy, 20 methoxy, ethoxy, amino, dimethylamino and diethylamino,

R⁴ represents methyl, ethyl, trifluoromethyl or phenyl,

R⁵ represents methyl or ethyl,

25

R⁶ represents cyano, carboxyl or C₁-C₄-alkoxycarbonyl, wherein the alkoxy moiety can be further substituted with a radical selected from the group consisting of hydroxy, methoxy, ethoxy, amino, mono- and di-C₁-C₄-alkylamino,

30

LeA 35 748 R⁷ represents hydrogen, methyl, ethyl or amino,

and

R^8 represents hydrogen.

5

3. Compounds of general formula (I) according to claim 1 or 2, wherein

R^1 and R^2 represent hydrogen,

10 R^3 represents fluoro, chloro, bromo, nitro, cyano, trifluoromethyl, methyl, methoxy or hydroxy,

R^4 represents methyl or trifluoromethyl,

15 R^5 represents methyl,

R^6 represents cyano, methoxycarbonyl or ethoxycarbonyl,

20 R^7 represents hydrogen, methyl or amino,

R^8 and R^9 represent hydrogen,

and

25 R^{10} represents fluoro, chloro, bromo, nitro, cyano, trifluoromethyl or methyl.

4. Compounds of general formula (I) according to claim 1, 2 or 3, wherein R^4 is methyl.

30

5. Compounds of general formula (I) according to claim 1, 2 or 3, wherein R⁵ is methyl.

6. Compounds of general formula (I) according to claim 1, 2 or 3, wherein R⁶ is methoxycarbonyl or ethoxycarbonyl.

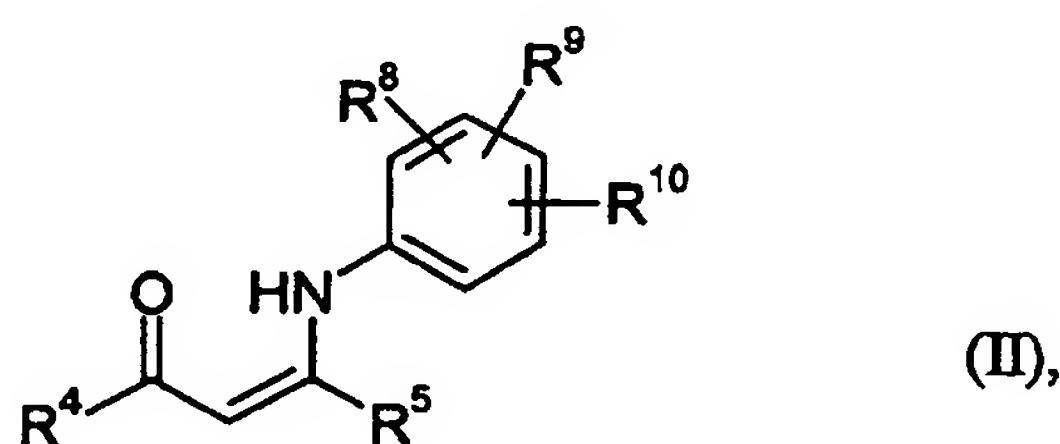
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7. Compounds of general formula (I) according to claim 1, 2 or 3, wherein R⁷ is hydrogen, methyl or amino.

10 8. Processes for synthesizing the compounds of general formula (I) according to claim 1, 2 or 3, characterized in that either

[A] compounds of the general formula (II)

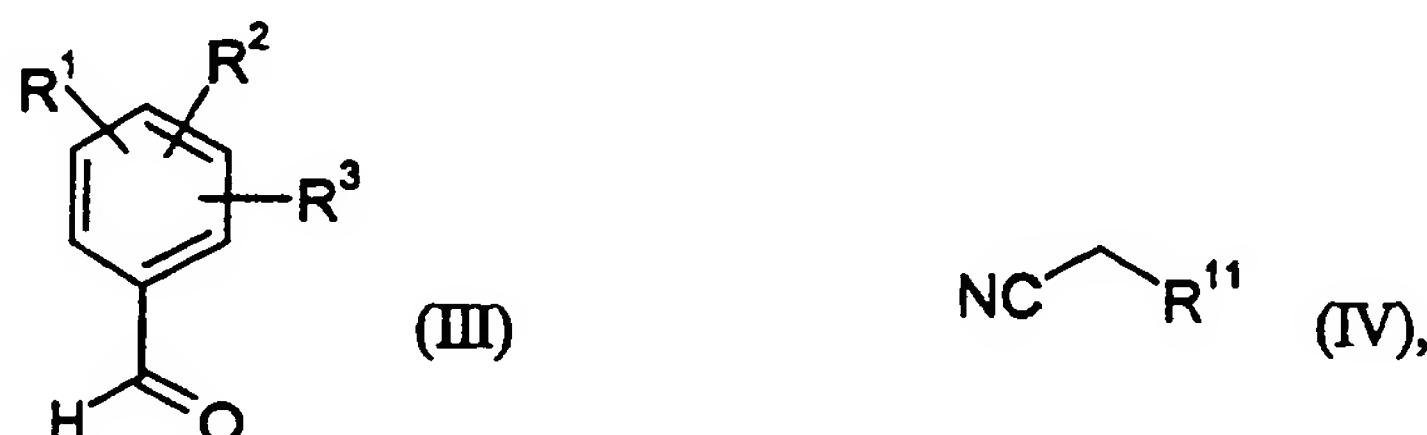
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wherein R⁴, R⁵, R⁸, R⁹ and R¹⁰ have the meaning described above,

20

are condensed in the presence of a base with compounds of the general formulas (III) and (IV)

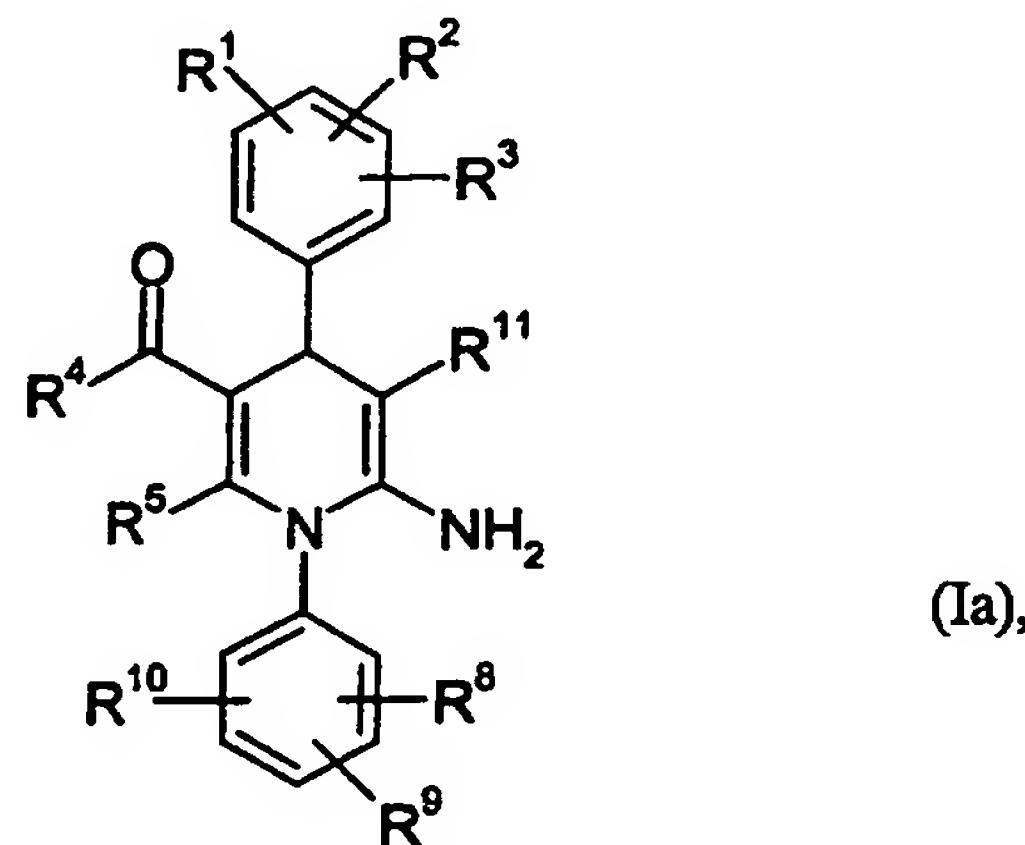


wherein R^1 , R^2 and R^3 have the meaning described above,

and

5 R^{11} represents cyano or C_1 - C_6 -alkoxycarbonyl,

to give compounds of the general formula (Ia)

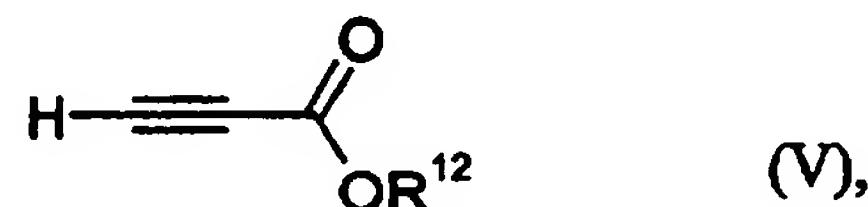


10

or

[B] compounds of the general formulas (II) and (III) are condensed in the presence of an acid with compounds of the general formula (V)

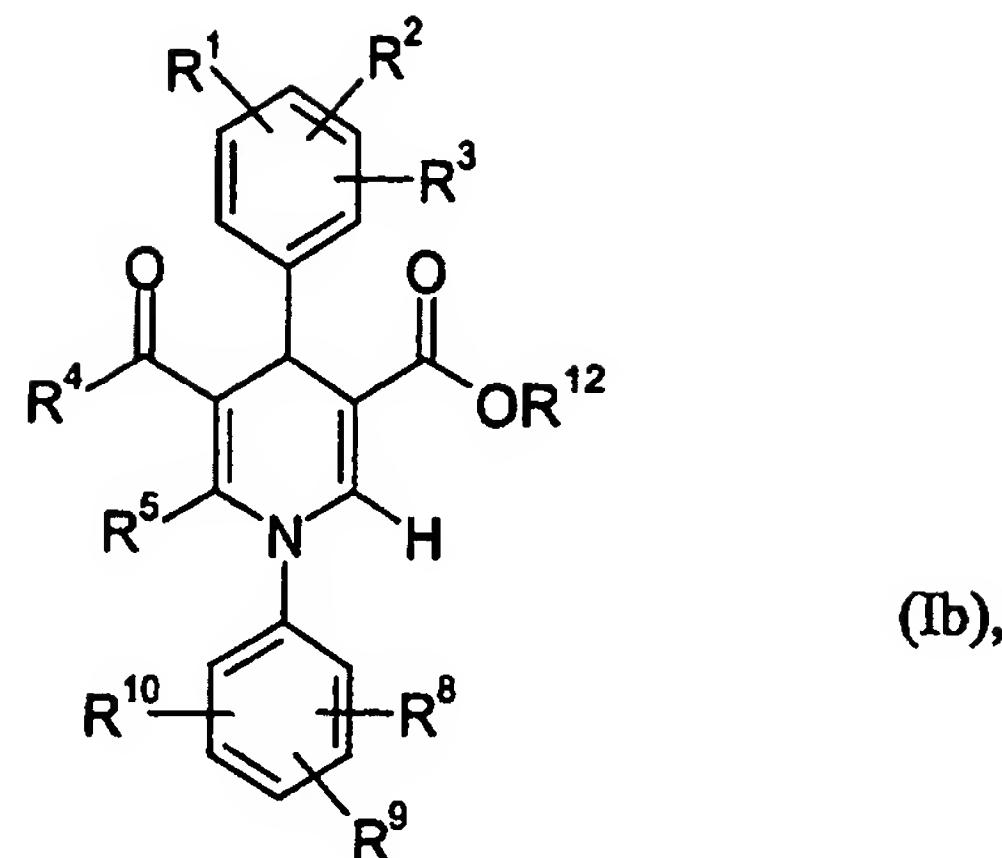
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wherein R^{12} represents C_1 - C_6 -alkyl,

to give compounds of the general formula (Ib)

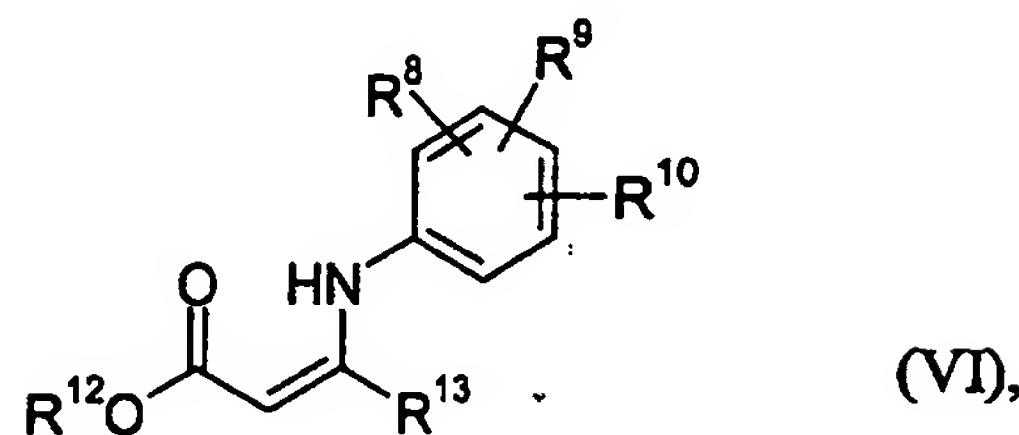
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or

[C] compounds of the general formula (VI)

5



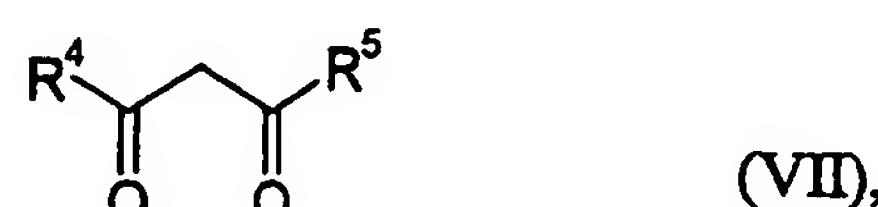
wherein R⁸, R⁹, R¹⁰ and R¹² have the meaning described above,

10

and

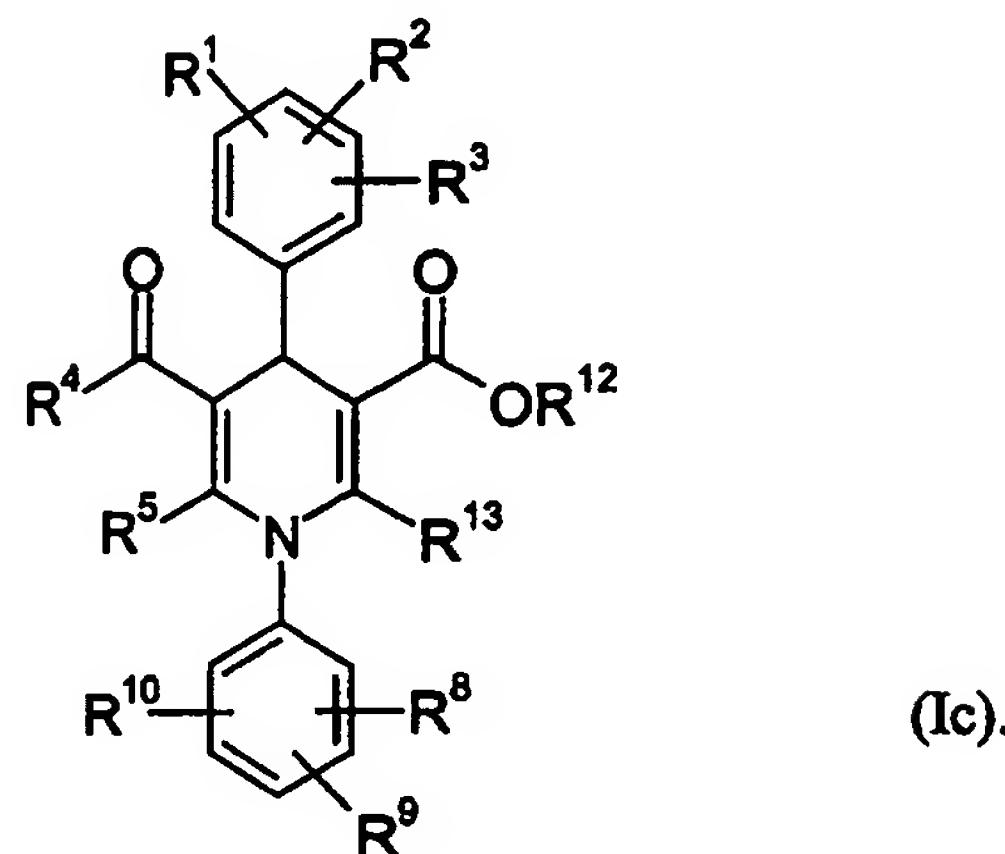
R¹³ represents C₁-C₄-alkyl,

15 are condensed in the presence of an acid or a base with compounds of the general formulas (III) and (VII)



wherein R⁴ and R⁵ have the meaning described above,

to give compounds of the general formula (Ic)



5

9. The composition containing at least one compound of general formula (I) according to claim 1, 2 or 3 and a pharmacologically acceptable diluent.

10

10. A composition according to claim 9 for the treatment of acute and chronic inflammatory processes.

15

11. The process for the preparation of compositions according to claim 10 and 11 characterized in that the compounds of general formula (I) according to claim 1, 2 or 3 together with customary auxiliaries are brought into a suitable application form.

12. Use compounds of general formula (I) according to claim 1, 2 or 3 for the preparation of medicaments.

20

13. Use according to claim 12 for the preparation of medicaments for the treatment of acute and chronic inflammatory processes.

14. Use according to claim 13, wherein the process is chronic obstructive pulmonary disease.

15. A compound according to claim 1, as hereinbefore specifically identified.
- 5 16. Process according to claim 8, when carried out substantially as hereinbefore described in any one of the Preparation Examples.



INVESTOR IN PEOPLE

Application No: GB 0130553.1
Claims searched: 1-16

Examiner: Peter Davey
Date of search: 19 February 2003

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A		EP 1106614 A1 (PFIZER), see eg. claims 1 and 9

Categories:

X Document indicating lack of novelty or inventive step	A Document indicating technological background and/or state of the art.
Y Document indicating lack of inventive step if combined with one or more other documents of same category.	P Document published on or after the declared priority date but before the filing date of this invention.
& Member of the same patent family	E Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC⁶:

Worldwide search of patent documents classified in the following areas of the IPC⁷:

C07D

The following online and other databases have been used in the preparation of this search report:

WPI, EPODOC, JAPIO, CAS ONLINE